

PIRI ISSUE PAPERS

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PIRI ISSUE PAPER

Issues Associated With Natural Attenuation

by

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There are a multitude of technical and policy issues associated with using natural attenuation to remediate leaking USTs containing petroleum. The U.S. Environmental Protection Agency (EPA) believes that natural attenuation is a viable option for remediating leaking UST sites and that it is compatible with the risk-based corrective action approach. The majority of States allow natural attenuation, and most State Funds reimburse for associated expenditures. Some State implementing agencies do not, however, allow the use of natural attenuation.

Background

The use of natural attenuation at UST sites with petroleum releases has increased significantly over the past few years. As of 1995, natural attenuation is the second most popular option for soil sites; it is being used at roughly 29,000 sites or at 28 percent of the active contaminated soil universe. Natural attenuation is the most common treatment option at groundwater sites; it is being used at 17,000 sites or about 47 percent of the active contaminated groundwater universe.

The first issue for natural attenuation is whether or not it is accepted as a remediation option by a State. Although most States allow the use of natural attenuation, there are at least seven States that do not allow it as the sole remediation option. About 43 States have established or are planning to establish guidance, regulations, or statutes on natural attenuation. At this time, MTBE does not appear to readily biodegrade. EPA, therefore, does not currently believe that natural attenuation is an appropriate remediation option for MTBE. EPA encourages States to incorporate MTBE as a chemical of concern into their RBCA programs. About 10 States do not allow natural attenuation if MTBE is a chemical of concern; this number may begin to increase as more States start testing for the presence of MTBE. However, the presence of MTBE at a site should not preclude natural attenuation as a remedy for other contaminants (e.g., BTEX) at a site.

Natural attenuation is one of several remediation options possible at a site; it is not a "default" option. As with any remediation option, natural attenuation should be evaluated for its appropriateness based on the risks, the site characteristics, and the potential to achieve remediation objectives at each individual site.

The next issue is "how to implement" the use of natural attenuation. EPA is developing an EPA/OSWER Directive entitled *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* for use at petroleum and hazardous waste sites and hopes to release it by September 1997. ASTM is developing a *Standard Guide for Remediation by Natural Attenuation at Petroleum Sites* and plans to release it soon. These documents will assist States in developing processes and criteria for implementing natural attenuation as a remedy.

Natural Attenuation Versus No Further Action

If natural attenuation is chosen as a remediation option, then, by definition, the site is not "protective [of human health and the environment]." The site would be designated as a No Further Action (NFA) site if it were "protective [of human health and the environment]"; hence, work is still needed at the site. Natural attenuation is an active process that includes site characterization, risk assessment, and monitoring of remediation progress. EPA believes that free product removal is essential when remediating by natural attenuation and that the cleanup is not complete until the site has reached the cleanup levels of the State or local implementing agency. EPA also believes that it is important for the implementing agency to include contingency measures in its planning, in case natural attenuation is shown through monitoring to be unable to meet the cleanup levels.

Of course, States can and do incorporate flexibility in how they implement and oversee free product removal. One must remember that the Federal UST regulations pertain only to Federally regulated USTs that contain petroleum (and hazardous substances). Petroleum from other sources is not subject to the Federal UST regulations, although EPA's Oil Pollution Act, Resource Conservation Recovery Act (RCRA), or Safe Drinking Water Act (SDWA) may apply. In addition, the Federal UST regulations state that "...owners and operators must remove free product to the maximum extent practicable as determined by the implementing agency." For example, site-specific (e.g., geological) conditions may render free product removal impractical. In this case or at other sites as determined by the implementing agency, free product removal would probably be assessed within a risk-based framework base that evaluates proximity to potential receptors, land use, groundwater classification, and other factors as determined by the State or local implementing agency. EPA recommends that the responsible party work closely with the implementing agency to ensure that it complies with State requirements.

Site Characterizations

As with any remediation alternative, an adequate site characterization is essential. Three types of site-specific information or "lines of evidence" may be used: Primary, secondary, and tertiary. Each is described below.

- ◆ Primary lines of evidence are data from historical groundwater and/or soil chemistry samples that demonstrate a clear and meaningful trend of declining contaminant mass and/or concentrations at appropriate monitoring or sampling points. Primary lines of evidence are used to determine whether plumes are shrinking or stable.
- ◆ Secondary lines of evidence include data from the site characterization that indirectly demonstrate the type of natural attenuation processes active at the site and determine the rate at which such processes will reduce contaminant concentrations to required levels. For example, the rate of biodegradation can be indirectly determined by measuring the levels of dissolved oxygen and nitrate, iron (II), sulfate, methane, carbon dioxide, and other parameters.
- ◆ Tertiary lines of evidence include data from field or microcosm studies (conducted in or with actual contaminated site media) that directly demonstrate microbial activity in the soil or aquifer material and its ability to degrade the contaminants of concern.

EPA recommends collecting both primary and secondary lines of evidence unless there are sufficient historical data (as determined by the State or local implementing agency) to adequately

characterize the site. The amount and type of information necessary will depend upon site-specific factors including the hydrogeological settings, the size and nature of the problem, the existence and proximity of any receptors, and the potential risk to receptors. For petroleum sites, EPA does not expect that tertiary lines of evidence will be necessary. ASTM is developing similar recommendations. Nineteen States currently require secondary lines of evidence (i.e., geochemical indicators) for natural attenuation.

Remediation Objectives

Every remediation action plan must have clearly defined objectives. These objectives include identifying cleanup levels or performance requirements, determining points of compliance, and establishing acceptable timeframes for cleanup. Once the remediation objectives are established, natural attenuation can be evaluated for suitability as a remediation alternative. Natural attenuation may be the sole remediation option, a component of the remediation action plan, or unsuitable--depending on the site.

Performance Monitoring

EPA emphasizes that performance monitoring is essential when relying on natural attenuation as a remediation option. Performance monitoring is needed to demonstrate that natural attenuation is occurring according to expectations, to detect contaminant migration or any new releases from the site, and to verify the attainment of cleanup objectives. EPA stresses that performance monitoring is required as long as contamination levels remain above required cleanup levels at points of compliance as determined by the State implementing agency. The majority of States require quarterly monitoring generally for a period of 1 to 3 years or until definite trends are established or standards are attained.

Practical and Economic Issues

The potential advantages of natural attenuation include: The generation of less remediation wastes; less disruption of the environment; ease of use in conjunction with other remediation technologies; no equipment down time; and likelihood of lower overall costs than from active remediation. There are, however, a number of disadvantages including: Longer timeframes may be required to achieve remediation goals; the public may not perceive the process correctly; site characterizations can be more costly and complex; responsibility must be assumed for performance monitoring; the potential exists for continued migration; and implementing a contingency plan that uses a more active remediation alternative might be necessary if natural attenuation fails.

The disadvantages can have economic implications: Property transfers may be delayed or stopped; longer timeframes may not be compatible with future land uses; active remediation may be more economical than performance monitoring at certain sites; and liability could be an issue for present and future land users. In addition, the owner and operator may find it more difficult to obtain insurance. EPA and the States are working closely with the private sector to overcome some of these issues, but many of them will need to be resolved on a site-specific basis.

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The Definition Of Contaminant In Risk-Based Corrective Actions

by
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When State regulatory agencies are integrating risk-based corrective action (RBCA) into their UST programs, they may need to reconsider their definition and use of terms such as *contaminant*, *contamination*, and *contaminated media*. Historically, many programs have defined a contaminant as any detection of a chemical in environmental media. To be consistent with the underlying concepts of RBCA, it may be more appropriate to define *contaminant* in terms of the conditions that pose an unacceptable threat to human health and/or the environment.

Defining Contaminant

In adopting a RBCA program, the acceptance that limited quantities of chemicals of concern (COCs) may remain in environmental media without presenting an unacceptable threat to human health and the environment is fundamental. In other words, the mere presence of a chemical in a medium does not necessarily make that medium contaminated. One of the goals of RBCA is to establish those specific conditions which pose an unacceptable threat to human or environmental receptors. As a starting point for defining the key terminology, the following questions must be addressed:

- ♦ What is a *chemical of concern (COC)* and how does it differ from a *contaminant*?
- ♦ When does the presence of a COC result in *contaminated media*?
- ♦ How does a State agency regulate *contaminated media*?
- ♦ How does one determine which concentration levels of COCs will pose an unacceptable present or future threat to human health or the environment?

Chemical of concern (COC) can be defined by referring to the statutory and regulatory definitions for solid waste, industrial solid waste, municipal solid waste, radioactive waste, hazardous waste, hazardous substance, petroleum substance, and other regulated substances. To define these substances, individual States should look to their own administrative code and/or the Code of Federal Regulations. For petroleum underground storage tanks, the list of COCs should be relatively limited.

A COC becomes a *contaminant* when the COC occurs at a concentration that poses an unacceptable threat to human health and the environment. The RBCA program will establish that particular concentration limit specific to land use and exposure scenario.

Contaminated media means soil, sediment, groundwater, surface water, or air that contains COCs at levels which exceed human health or environmentally protective levels as determined consistent with the State's RBCA program. Most States regulate contaminated media, that is, specific chemicals as they occur in air, water, soil, and sediment.

Historical Perspective

Historically, it has not been unusual for a State to use *contaminant* to mean any occurrence of a regulated chemical in soil, sediment, groundwater, surface water, air, or other media above the currently established level of detection. By defaulting to this definition, the State may feel that it is enacting its responsibility for protecting the public; the State cannot provide the regulated community with anything that may be misinterpreted as a permit to pollute or discharge. This definition of contaminant may be perceived to be protective [of human health and the environment], but it has not necessarily resulted in the remediation or removal of more contaminated media or other measurable benefits of reducing human health risks or ecological impacts. The following problems have been identified with a definition based on limit of detection:

- ◆ Many chemicals occur at background concentrations in soil, water, or air by their natural occurrence in the environment. Typically, these chemicals are not regarded as contaminants solely because they are detected in the laboratory.
- ◆ There is a stigma associated with the words *contaminant* and *contamination*, potentially resulting in property devaluation and/or third-party concerns. By defining *contamination* on the basis of occurrence only, unnecessary concern is generated and this stigma is automatically attached to a property before the potential risks associated with the occurrence of a chemical have been evaluated. This thinking is certainly not consistent with rational risk-based decision-making.
- ◆ There are inherent problems with the use of the laboratory levels of detection that will impart much uncertainty to the definition.
- ◆ The level of detection for a chemical may be specific to the laboratory method used to analyze for that particular chemical; one chemical can have various detection limits depending on the laboratory method used in that particular State or agency program.
- ◆ Detection limits are ever changing with advances in analytical chemistry and availability of better laboratory equipment. In many cases, chemicals can be detected well below background levels.
- ◆ The accurate detection of a chemical in a sample can be impeded by the occurrence of other chemicals in the sample (e.g., matrix interference).

Alternatively, the risk-based definition for contaminant takes into account the acceptable level of risk, land-use definitions (i.e., current and reasonable potential future), and exposure scenario (i.e., completed pathways). Inherent in the State-implemented RBCA program will be the demonstration that the regulated chemical is present at a concentration that is deemed to pose an unacceptable risk to human health or the environment and, therefore, is undesirable. A critical change in philosophy as it applies to these definitions might help to eliminate the automatic assignment of the "contamination" stigma to all properties where COCs are detected.

Precedent Setting Programs

There is a precedent in many State and Federal regulatory programs to allow levels of chemicals of concern to remain in environmental media without becoming contaminated media. Most States have accepted this concept in their adoption of MCLs or State drinking water standards and permitted air emissions and surface water discharges. Each State can look to its specific programs for numerous

examples of situations when acceptable levels of chemicals in soil, water, or air do not create contaminated media.

Recommendation

Establish the goals of the State-specific RBCA program. Develop definitions that are consistent with the goals as part of the implementation process. Consider existing statutory and regulatory definitions to avoid conflict with existing State regulatory programs.

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No Further Action Letters In Risk-Based Corrective Actions by Chet Clarke, Texas Natural Resource Conservation Commission

A primary goal of environmental regulatory programs is the protection of human health and the environment. Beyond protection of human health and the environment, a primary goal of responsible parties is to achieve in a timely and cost-effective manner "No Further Action" (NFA) status which supports some degree of certainty. NFA letters are significant in that they should:

- ◆ Represent an official regulatory affirmation that a site adequately protects human health and the environment for the intended use of the site;
- ◆ Note the end to corrective action; and
- ◆ Document any property use restrictions.

Regulators, responsible parties, landowners, investors, and lenders all benefit from NFA status. Unfortunately, the vague language often included in NFA letters (e.g., no further action at this time; no further action but case may be reopened at a future time) thwarts much of the benefit derived from NFA status for all parties involved. Responsible parties need to have reasonable confidence that a corrective action matter is resolved. Landowners also need an NFA letter that imparts reasonable certainty to the closure to avoid an unnecessary stigma on the property which may diminish property values and turn an otherwise lucrative property transaction into an unacceptable economic risk for investors and lenders.

Regulators may be concerned that the NFA status may be inappropriately viewed as an end to environmental liability. Generally, there is no end to environmental liability with the issuance of an NFA letter. The NFA letter is a notice of the end of corrective action based on reported site conditions and land use and generally does not address environmental liability. (Each regulatory entity should verify.) Because the NFA letter does not address environmental liability, "at this time" language imparts uncertainty and complicity into the NFA statement.

Clearly, the issuance of NFA letters is important, and the wording of NFA letters is critical. In developing NFA letters, several factors should be considered. The first is that environmental regulatory agencies generally have clear authority to compel corrective actions when necessary to protect human health and the environment from contamination sites regardless of any assigned NFA status. In other words, "at this time" language may be duplicative and may cause unnecessary concern as NFA status may not terminate regulatory authority. Regulatory agencies may want to investigate their authority in this regard.

Second, signed statements from responsible parties and consultants attending to the appropriateness of the site for NFA status may impart a greater regulatory confidence in assignment of NFA status in that all parties have a vested interest/responsibility in the closure decision. More confidence in the completeness and validity of site information imparts greater confidence in decision making on the part of all parties involved.

Third, specific conditions for closure may be incorporated into NFA letters when restricted land use or other conditions must be maintained for NFA status to remain in effect. Such NFA letters should

clearly indicate what actions/conditions will necessitate further corrective action. For example, language such as "NFA status will be in effect so long as the site is not used for residential purposes" can be incorporated into NFA letters to indicate to all parties involved that the property is suitable for other land uses which, in fact, may represent greater economic advantage than residential land use. Using this language may not limit authority to reopen cases when needed to protect human health and the environment, but it will lay out use of the property that can be confidently exercised. In some instances, institutional controls may be necessary to ensure long term protection and notification when land-use limitations are the basis for closure.

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Selection Of Carcinogenic Target Risk Levels For Soil And Groundwater Remediation
by
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Target risk levels dictate the degree of human health protection to be achieved by risk-based soil and groundwater cleanup standards. The degree of conservatism incorporated in the selection of applicable target risk levels significantly affects cleanup standard calculations and associated remediation action cost. This paper reviews the significance of the carcinogenic target risk level and provides background information regarding target risk values incorporated in various regulatory programs. This paper does not discuss target risk levels for non-carcinogenic chemicals.

Significance of Target Risk Levels

The target risk level serves as a starting point in the development of soil and groundwater cleanup standards. The adverse human health effect is quantified by the individual excess lifetime cancer risk (IELCR). The IELCR represents the incremental (over background) probability of an exposed individual's getting cancer (i.e., a risk occurring in excess of or above and beyond other risks for cancer such as diet, smoking, heredity). Cleanup standards calculated on the basis of excess risk limits correspond to allowable levels in excess of the background concentrations of the chemicals of concern normally present in the source media. In the "forward mode" of risk assessment, the end result of a baseline risk assessment is an estimated IELCR at the point of exposure. If the IELCR exceeds the regulatory specified target risk level, remediation measures are necessary. In the "backward mode" of risk assessment, the acceptable level of risk at the point of exposure, as specified by the regulatory authority, is used to back-calculate soil or groundwater target cleanup concentrations for the source area. If the target concentrations exceed the actual concentrations in the source area, no remediation measures are necessary.

Back-calculated cleanup standards are directly proportional to the applicable target risk level. For example, if the acceptable risk level for benzene in residential drinking water is increased from 10^{-6} to 10^{-4} , the target concentration for benzene changes from 2.94 $\mu\text{g/l}$ to 294 $\mu\text{g/l}$ (ASTM, 1995), based on the application of standard reasonable maximum exposure (RME) factors. In practical terms, this means that persons ingesting water containing 2.94 $\mu\text{g/l}$ of benzene on a daily basis for 30 years will incur an additional 1 in 1,000,000 risk of cancer, while persons ingesting water containing 294 $\mu\text{g/l}$ of benzene, incur an additional 1 in 10,000 risk of cancer. Persons who do not ingest this water incur no additional risk. Soil and groundwater cleanup standards for all exposure pathways exhibit a similar sensitivity to the acceptable risk levels.

Examples Of Acceptable Carcinogenic Risk Levels In Existing Regulatory Programs

There is a general perception that a carcinogenic risk limit of 10^{-6} represents a standard risk protection factor embodied in State and Federal regulations. However, careful review of historical standards reveals use of a broad range of effective risk limits, wherein 10^{-6} represents a lower bound zero risk value (FSC, 1980). Also, there is an apparent historical trend for the use of greater acceptable risk

levels as the conservative nature of risk assessment calculations has been recognized. Examples of existing regulatory standards are listed below.

- ◆ U.S. Food and Drug Administration (FDA): A risk-based recommended standard of 10^{-8} was first proposed by Mantel and Bryan in 1961. In 1977, the FDA instead used 10^{-6} as a risk-based standard for food residues of animal drugs after originally proposing the 10^{-8} risk level in 1973. The 10^{-6} target risk level used by the FDA for meat products represents essentially zero risk.
- ◆ Mean Regulatory Trigger: Travis et al (1987) reviewed over 132 Federal regulatory decisions and concluded that every situation involving a risk due to chemical exposure of 4×10^{-3} triggered a regulation. Further, action was never taken to reduce upper-bound cancer risks below 1×10^{-6} . The decisions to regulate at levels between 4×10^{-3} and 1×10^{-6} were based on size of exposed population, technical feasibility, and costs.
- ◆ Superfund NCP: In its final National Contingency Plan for Superfund site remediation (USEPA, 1990a), EPA codified a range of acceptable risks (i.e., 1×10^{-4} to 1×10^{-6}) as a basis for remediation of Superfund sites. The decision to use a range of acceptable risk levels and not specify 1×10^{-6} as the ultimate cleanup goal was reaffirmed in subsequent Agency guidance (USEPA, 1991).
- ◆ Safe Drinking Water Act: The starting point for most MCLs is a 10^{-6} carcinogenic target risk level, but many MCLs exceed the 10^{-6} risk level for practical and economic reasons. For example, the Federal MCL for beryllium is based on a carcinogenic target risk level of 2×10^{-4} for these reasons.
- ◆ State RBCA Target Risk Policies: A recent survey of States participating in the EPA/ASTM RBCA Training Initiative shows that roughly one-third of them have selected carcinogenic target risk limits in the range of 10^{-5} to 10^{-4} for development of risk-based soil and groundwater cleanup standards. Of the 14 States responding to the 1995 RBCA Policy Issue Survey, nine had tentatively selected a 10^{-6} carcinogenic target risk level or a drinking water MCL as the basis for derivation of cleanup limits, while five intend to employ either a 10^{-5} or 10^{-4} target risk limit depending on applicable land-use conditions (Conner et al., 1997).
- ◆ EPA Hazardous Waste Management System Toxicity Characteristics Revision: In its Hazardous Waste Management System Toxicity Characteristics Revisions (USEPA, 1990a), USEPA has selected a single risk level of 1×10^{-5} . EPA believes that "due to the conservative nature of the exposure scenario and the underlying health criteria," a 10^{-5} target risk level is the highest risk level that is likely to be experienced by an exposed population.
- ◆ Clean Air Act Amendments (1990b): The Clean Air Act, as amended, 42 USC 7412(f), contains a provision which specifically references and endorses the basis on which EPA determined acceptable risk and margin of safety in the benzene NESHAP regulations. Under this policy, EPA considers all relevant risk factors, including uncertainty in the risk estimates, with a presumptive risk of approximately 1 in 10,000 (10^{-4}) in making acceptable risk decisions under Section 112 (hazardous air pollutants) of the Clean Air Act (USEPA, 1989).
- ◆ National Council on Radon Protection: While evaluating radon exposures, the National Council on Radiation Protection and Management adopted a remediation action level corresponding to a

lifetime risk of 2.8×10^{-2} . This was adopted to balance risk and feasibility. A lower level would have resulted in "a great societal cost."

Thus, although the common belief is that Federal regulations are written with an acceptable risk of 10^{-6} , this is not true as is clear from the above examples.

Options For Defining An Acceptable Carcinogenic Level Of Risk

Considering that 10^{-6} is an arbitrary number as is any other number (e.g., 10^{-5} or 10^{-4}), the following are a few policy options available to the decision makers:

- ◆ A single specified acceptable risk level applicable for all carcinogens (i.e., the Bright-line standard such as 10^{-6} , 10^{-5}).
- ◆ Different specified risk levels depending on the weight-of-evidence classification of a chemical (i.e., 10^{-6} for A carcinogens, and 10^{-5} for B and C carcinogens, or 10^{-5} for A carcinogens and 10^{-4} for B or C carcinogens).
- ◆ A range of acceptable risk levels (e.g., 10^{-4} to 10^{-6}) with accompanying discussion as to how the range is to be used (e.g., land use).
- ◆ Lower acceptable risk level for actual exposures, higher acceptable risk level for potential future exposures. This may be justified on the basis that most of the petroleum-derived chemicals are known to naturally attenuate.

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**PRI
ISSUE PAPER**

Off-Site Movement Of Chemical(s) Of Concern In Risk-Based Corrective Actions

by
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The term "off-site" refers to properties or areas that are not within the boundaries of the property on which the release occurred or where the source area(s) is located. The primary driver (from a pure risk-based corrective action perspective) for considering the off-site movement of a chemical of concern is the actual or potential exposure of a receptor to a chemical of concern at a concentration that presents an unacceptable risk. There are, however, a number of non-risk-related issues that impact (and many times drive) the decisions associated with off-site movement. These issues include:

- ◆ "Trespass" or the concept that the chemical of concern was caused to exist off-site without the permission or consent of the property owner;
- ◆ "Property devaluation" or the concept that the property value has been lessened by the stigma associated with the presence of the chemicals of concern on a property even though the presence of that chemical does not present a risk;
- ◆ "Diminished use" or the concept that the property can not be fully utilized or that its use is partially restricted by the presence of chemical of concern; and
- ◆ "Nondegradation" or the concept that the environment has been degraded and should be restored to its original quality even though the chemicals of concern do not present a risk. (This is particularly true for ground water.)

Off-site movement is a difficult issue for a State program to address because it is driven not only by protection of human health and the environment but also by subjective criteria, emotional responses, and non-health-based considerations. From a RBCA perspective, the ideal approach to this issue is to address it based purely on the actual or potential risk that is posed by the chemical of concern, leaving the other issues to be resolved among the stakeholders under common law principles. This approach addresses the acceptable risk associated with a source area based on known or reasonably anticipated point(s) of exposure. Although this approach provides considerable flexibility, implementing it may be difficult because of current State policies (e.g., nondegradation) and a general reluctance to accept the concept of site-specific acceptable concentrations of chemicals of concern in the groundwater or soil.

Different Approaches For State Programs

As described in the following paragraphs, there are several alternate approaches being considered by State programs. The most restrictive approach is to establish groundwater standards (i.e., apply drinking water standards or background levels) and require that all groundwater, on or off the site, meet these standards. This approach does not take into account the use of the groundwater, the potential for exposure to the chemicals of concern, or the technological limitations of remediation methods. It requires the implementation of a complex and sometimes extensive remediation action system to reduce

concentrations of chemicals of concern in the soil and groundwater simply to achieve the standard. It assumes that all soil and groundwater can be restored to pre-release condition.

A State could allow a demonstration showing that existing levels of chemicals of concern do not present a current or future unacceptable risk but requiring that concentrations of chemicals of concern in the groundwater ultimately reach established groundwater standards within an identified timeframe through natural attenuation. This approach recognizes that natural attenuation processes will reduce the concentrations of chemicals of concern over distance and time. This approach does, however, require that an established groundwater standard be achieved; typically, it will require the implementation of a remediation action plan if the standard cannot be achieved in the timeframe identified.

A State could assume that the property line is the point of exposure for the purpose of calculating site-specific target levels at the source area. This approach recognizes the use of a point of exposure (e.g., a drinking water well, surface water) but artificially fixes the location of this point rather than specifically establishing it at the actual or reasonably potential future point where a receptor may be exposed to the chemicals of concern. For smaller sites or sites where the source is close to the property line and there is no likely future receptor in close proximity, this approach is not significantly different from the one above.

A State could assume an arbitrary point of exposure set at a defined (limited) distance (often set as groundwater travel time) down-gradient of the source, regardless of property size, for the purpose of calculating site-specific target levels at the source area. This approach recognizes both the difficulty of establishing reasonably potential future points of exposure and the problems associated with using the property line as a point of exposure. It still does not address actual points of exposure unless they are within the defined distance; it could, therefore, be conservative in some cases.

Policy Considerations

There are three considerations or policy decisions that must be evaluated in order to define an approach to the off-site movement of chemicals of concern: Land use, groundwater use, and point(s) of exposure. Land use (current and reasonably potential future) includes the land use of the site and the surrounding property. Determination of land use should be based on the following factors:

- ♦ The current land use of the property;
- ♦ The current land use of properties immediately adjacent and across any streets from the property;
- ♦ The current zoning or planning designation for the property;
- ♦ The current zoning or planning designation for the surrounding properties;
- ♦ Reasonably potential future land use of the property using the duration of exposure as the maximum time into the future to evaluate; and
- ♦ Reasonably potential future land use of the surrounding properties using the durations of exposure as the maximum time into the future to evaluate.

Groundwater use (current and reasonably potential future) includes the quality and potential use of the groundwater (groundwater classification) as a drinking water source and State nondegradation policies. While this determination can be linked to the use of the property, it is typically addressed as a separate issue. Determination and documentation of groundwater use could include the development of a groundwater classification system based on characteristics such as urban setting, yield rates, existing quality (both ambient chemicals resulting from human activities and natural quality as measured against the primary and secondary drinking water standards).

Determination of the location of the point(s) of exposure, specifically when a known or reasonably potential future receptor is not identified, could include:

- ◆ An actual or known location of a current or future receptor;
- ◆ The determination of an assumed location for a receptor in cases where future use is likely, but the exact circumstances for that use cannot be determined; or
- ◆ A calculated position based on a time/distance relationship (e.g., groundwater travel time).

It is important that a RBCA program identify these three policy decisions to ensure a consistent approach that clearly defines unacceptable risk.

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**Institutional Controls In Risk-Based Corrective Actions
by
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The use of institutional mechanisms to memorialize land and resource-use constraints and provide for safety has been used extensively throughout the United States. Federal, State and local laws and codes have required various institutional control mechanisms for conservation area protection, aquifer protection, historic preservation, development limitations, hazardous and solid waste facility closure, notice of contaminated sites, notice of buried utilities, and the like. Whenever institutional controls are used, a control requirement (or notice) is recorded with the appropriate regulatory agency (or agencies) where reasonable diligent inquiry (required by law in many instances) would uncover the existence of such notice. Examples of different types of institutional controls are: Structure-use restrictions, land-use restrictions, natural resource-use restrictions, well restriction areas, deed restrictions, deed notices, declaration of environmental restrictions, access controls, monitoring requirements, site posting requirements, information distribution, notification in closure letter, restrictive covenants, and Federal/State/county/local registries.

In the area of site remediation, returning land and groundwater to conditions acceptable for unrestricted residential use would be ideal, but the limitations of public and private-party funds tell us that this goal can never be achieved. Through the experience in risk-based corrective action and the need for remediation that is "protective [of human health and the environment]" and cost effective, the doors have opened for the use of institutional controls. In a 1995 survey of States conducted by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), 14 of 27 responding States acknowledged the use of institutional controls in site remediation. New Jersey defines "institutional controls" as "...a mechanism used to limit human activities at or near a contaminated site, or to ensure effectiveness of the remediation action, over time, when contaminants remain at a contaminated site in levels or concentrations above the applicable remediation standard that would allow for unrestricted use of that property. Institutional controls may include, without limitation, structure, land, and natural resource-use restrictions, well restriction areas, and deed notices."

Institutional controls are effective when the definition of "what contamination can remain at a site and under what conditions" or "how clean is clean" is defined based upon current land-use and exposure scenarios; particularly when the continued existence of such "protective" conditions is beyond the control of the regulatory agency. As an alternative to cleaning a site to levels that would be considered "safe" for unrestricted use, an institutional control can provide notice of exposure elimination, system maintenance (e.g., engineering control, capping), or land-use constraints (e.g., nonresidential use only). The institutional control, for example, could require notification to the approving agency prior to any disturbance of the land or change of land use that would create an unacceptable exposure.

The goal of State and Federal cleanup programs is to provide a regulatory structure in which cost-effective remediation decisions that are protective of human health and the environment can be made; the use of institutional controls provides for flexibility in remediation decision making. Institutional controls should be designed to remain protective over time, especially when risk-based remediation decisions are made based upon current land and resource use and maintenance of engineering controls. Remediation decisions memorialized in institutional controls should "run" with the land (e.g., deed notices, use

restrictions) or property file (i.e., be filed with the appropriate local/county/State land/resource-use control agencies) and, as needed, have affirmative obligations for maintenance requirements which are passed on to the prospective purchaser/operator.

Future land-use consideration should also be a critical factor in determining the nature and use of institutional controls. The scope of the remediation strategy, which should be defined early in the remediation process, should be based upon future land-use considerations. Especially if property purchasers are involved, the scope of the remediation effort and the use of any institutional controls should be consistent with the purchaser's intended use of the property. Prospective property transactions may be affected or complicated by the existence of contamination that remains above levels acceptable for unrestricted use when liability is unclear or contamination is not well defined.

Generating the data necessary to define the "scope" of the institutional control is a regulatory policy issue. The precision of soil and groundwater requirements and the reliance on field data versus modeling efforts should be considered. This is especially true for instances when the institutional control (e.g., deed notice) requires concurrence from the property owner. Delineation in these circumstances must be conducted in a manner to ensure that the ability of a property owner, purchaser, or neighboring property owner to use his/her property in a manner he/she chooses, to allow an understanding of any potential property value impacts, if any, and to allow for concurrence with the requested use restriction.

There are many factors that must be considered in designing a remediation program that incorporates and relies upon the use of institutional controls. Some of these public policy issues include:

- ◆ What are the State's land-use and population pressures for a change in the exposure scenario (e.g., conversion from industrial to residential use)?
- ◆ Should a State have penalty/enforcement capability if the maintenance requirements of the physical site are not followed (e.g., an allowance for breeches in exposure control mechanisms)?
- ◆ Will a responsible party have the option to place a "use restriction" on property he does not own? Will this be considered a taking of property?
- ◆ Should there be a preference for permanent remedies consistent with the National Contingency Plan and should the cost of permanent versus protective non-permanent remedies be considered?
- ◆ Are the repositories for the institutional controls reasonable for noticing current users, future purchasers, and resource and land-use decision makers? Is there redundancy in the multi-level notice requirements to prevent "system" notification failure? Can the diligent inquiry for such notices be required in law at the time of property transfer?
- ◆ Can the existing government structure be used to memorialize the institutional control mechanism? (E.g., will a county repository for deed notices serve to provide notice to future property purchasers?)
- ◆ Will local officials be notified of restrictions that may limit property use in a manner inconsistent with local zoning plans?

- ◆ Should the institutional control have an affirmative obligation to allow site inspections? Should this be required only if some form of "maintenance" is required?
- ◆ What level of public notice should be required?
- ◆ Is groundwater under a site considered State or private party property? If the site is located in a non-groundwater-use area, should all property owners be notified?
- ◆ Should a State establish a mechanism to evaluate the effectiveness of institutional controls over time?

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PIRI
ISSUE PAPER

**Groundwater Nondegradation Policies In The Development And Implementation Of
Risk-Based Corrective Action Programs**

by
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Since the development and publication of the American Society for Testing and Materials (ASTM) E 1739-95 *Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites* and EPA's OSWER Directive 9610.17, *Use of Risk-Based Decision Making in UST Corrective Action Programs*, the majority of State UST programs have pursued some application of risk-based cleanup standards within their respective environmental programs. Regulators in numerous States have, however, voiced concerns that risk-based corrective action (RBCA) conflicts with the groundwater nondegradation policies of their agencies. As a result, the degree to which ASTM/RBCA can be successfully implemented has been limited in these States.

While virtually every State's environmental regulatory agency adheres to a nondegradation policy of some sort, the form, substance, and interpretation of these policies vary greatly. Usually found in the "Introduction" or "General" sections of the State's environmental protection act, nondegradation language can also be found in specific statutes or laws in the preambles and/or actual texts of the regulatory codes. Some States have no enforceable nondegradation language; rather, the agency has merely stated such a policy. Nondegradation policies can take the form of groundwater standards or classifications, of remedial goals or objectives and, in rare cases, of actual enforceable remedial standards. As a rule, the intent of nondegradation policies is usually to prevent pollution and to protect the viability of natural resources and not to establish "zero tolerance" cleanup standards. Through broad interpretation, though, some States have historically used nondegradation policies for just that purpose.

In attempting to deal with a nondegradation policy in the process of implementing a RBCA program in any State, the first step is to fully understand the intent and meaning of the policy. Is the policy being properly interpreted by the implementing agency? Who is interpreting it? Is the language being interpreted literally or has supposition been applied? Can all parties agree upon an official interpretation and application?

The next step is to determine if the policy presents a hurdle or a road block. How invested is the implementing agency in seeking a solution? There may be an opportunity to seek a more favorable interpretation, and there may be some flexibility in the agency's application of the policy. A number of approaches can be applied to successfully implement an ASTM/RBCA program in States with nondegradation policies.

Legislation/Rulemaking

The most direct approach to dealing with a nondegradation policy is to change it through legislation or rulemaking. This approach, however, should generally be pursued after other approaches have been exhausted. The processes of legislative change and environmental rulemaking are time-intensive and unpredictable.

Strict Interpretation

Assuming that a consensus interpretation of the nondegradation policy has not been achieved among the parties, the opportunity exists for them to agree on an interpretation more favorable to the RBCA process. For example, it can be argued that the intent of a nondegradation policy is to prevent the degradation of a natural resource, and that once it becomes degraded other policies will have to be put in place to apply to the remedial efforts. This argument, however, should not be interpreted as a "license to pollute."

Standards Versus Objectives

In many cases, groundwater standards, cleanup standards, and cleanup objectives are considered synonymous. The most likely intent of groundwater standards is to protect the viability of potable aquifers and not to determine the level of cleanup necessary to apply to a contaminated aquifer. Groundwater standards may also serve to define classifications of groundwater. The argument should be made that not all groundwater is potable and that drinking water standards need only apply to aquifers which produce potable groundwater. Furthermore, there is a tremendous difference between objectives and standards. Arguably, cleanup standards should be set at realistically achievable levels commensurate with the risk posed by the contamination and the designated use of the aquifer, while cleanup objectives should represent targets or goals which might be technically, practicably, and financially unachievable.

Point Of Compliance

In the case of stringent generic cleanup standards, there may be an opportunity to apply the concept of risk by extending the point of compliance beyond the point of release. Many State codes allow for mixing zones. Also, many States base their cleanup standards on drinking water MCLs. By strict interpretation of the federal definition, MCLs apply only at the tap and not to the aquifer. Following this interpretation would allow for some flexibility to apply the principles of RBCA to the remedial effort.

Natural Attenuation

Although ASTM/RBCA applies the concepts of natural attenuation to the models that determine Tier II risk-based cleanup levels, there is still an opportunity to utilize natural attenuation in States that mandate strict concentration-based cleanup levels. Natural attenuation is one of many acceptable remediation options at UST sites. Please see the PIRI Issue Paper on natural attenuation for a discussion in greater detail.

Summary

There are certainly other approaches to dealing with nondegradation policies, probably as many as there are variations of the policies themselves. It is necessary for all involved parties to understand the intent and meaning of the policies and to develop a relationship that is conducive to seeking a solution. Finally, it is important to realize and understand that, notwithstanding their misinterpretation and misapplication, nondegradation policies are a vital part of an agency's environmental protection program. It should be the goal of all who endeavor to implement risk-based corrective action programs to achieve a balance between pollution prevention, exposure prevention and remedial action.

**PIRI
ISSUE PAPER**

Using TPH In Risk-Based Corrective Action

by

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Total Petroleum Hydrocarbon (TPH) analysis is widely used as a general measure of the presence of crude oil or petroleum product in soils. TPH is defined as the measurable amount of petroleum-based hydrocarbon in an environmental media (e.g., soil, water, sediments) and, thus, is dependent on analysis of the medium in which it is found. While providing an overall concentration of petroleum hydrocarbons, TPH itself is not a direct indicator of the risk (i.e., mobility, toxicity, and exposure to human and environmental receptors) posed by petroleum hydrocarbon contamination. Both mobility and toxicity are very dependent upon the relative amounts of individual (or groups or families of) constituents within a hydrocarbon mixture. For example, a crude oil may contain different types and amounts of aromatic compounds than does a gasoline. Other analysis or information in addition to a single TPH number must be used to relate TPH concentrations to risk.

This paper presents an overview of the measurement of TPH and the methods that have been used in the past to estimate the risk from TPH contamination. More recent developments, including those of the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), which is a national ad hoc committee that was formed to develop technically defensible risk-based approach to TPH, are also discussed. The paper concludes with examples of how the TPHCWG technology might be used by State regulatory agencies to incorporate TPH into a risk-based corrective action program.

Measurement Of TPH

A TPH method of analysis often used and required by many regulatory agencies is EPA Method 418.1. This method provides a "one number" value of TPH in an environmental media; it does not provide information on the composition (i.e., individual constituents such as benzene) of the hydrocarbon mixture. The amount of TPH measured by this method depends on the ability of the solvent used to extract the hydrocarbon from the environmental media and the absorption of infrared (IR) light by the hydrocarbons in the solvent extract. Method 418.1 is not specific to hydrocarbons; in fact, it can give false positive results when organic matter is extracted from the environmental media for analysis. In other words, TPH measurements do not always indicate petroleum contamination (e.g., humic acid).

Another analytical method commonly used for TPH is EPA Method 8015 Modified. This method reports the concentration of purgeable and extractable hydrocarbons which are also sometimes referred to as gasoline and diesel range organics (i.e., GRO and DRO) because the boiling point ranges of the hydrocarbon in each roughly corresponds to that of gasoline (i.e., C_6 to C_{10-12}) and diesel fuel (i.e., C_{8-12} to C_{24-26}), respectively. Purgeable hydrocarbons are measured by purge-and-trap gas chromatography (GC) analysis using a flame ionization detector (FID), while the extractable hydrocarbons are analyzed by GC following extraction with a solvent and subsequent concentration of the extract by evaporation. While more detailed information is generated by this method (e.g., GC chromatograms), the results are most frequently reported as single numbers for purgeable and extractable hydrocarbons.

The Massachusetts Department of Environmental Protection (MADEP) has developed a method

based on 8015 Modified which gives a measure of the aromatic content of the hydrocarbon in each of several carbon number ranges. In the MADEP method, the lighter hydrocarbon fractions (i.e., carbon numbers from C_6 to C_{12}) are analyzed by purge-and-trap GC analysis using a flame ionization detector (FID) to measure the total hydrocarbons and a photo ionization detector (PID) to measure the aromatics (e.g., benzene) with the aliphatic (e.g., hexane) component of the TPH being found by difference. The aromatic and aliphatic fractions are divided into carbon number fractions based on the normal alkanes (e.g., n-octane) as markers. The heavier hydrocarbons (i.e., C_{12} to C_{26}) are analyzed using an extraction procedure followed by a column separation using silica gel (Modified EPA Method 3630) of the aromatic and aliphatic groupings or fractions. The two fractions are then analyzed using GC-FID. PAH markers and n-alkane markers are used to divide the heavier aromatic and aliphatic fractions by carbon number, respectively.

The MADEP method is based on standard EPA methods (i.e., 8020/8015 Modified) which allows it to be easily implemented by contract laboratories. However, there are some concerns or issues about the method. One issue is that the PID is not completely selective for aromatics (i.e., it does respond to some aliphatic compounds). Thus, this approach can lead to an overestimate of the more mobile and toxic aromatic content. Another issue with this analytical approach is that the results from the two analyses (i.e., purgeable and extractable hydrocarbons) can overlap in carbon number and thus may not be simply added back together to get a total TPH concentration. The performance of this method on real hydrocarbon products may be limited.

The TPH Criteria Working Group has developed a method for identifying and quantifying the presence of the groups or fractions with similar mobility in soils. The technique is based on EPA Method 3611 (Alumina Column Cleanup and Separation of Petroleum Wastes) and EPA Method 3630 (Silica Gel Cleanup), which are used to fractionate the hydrocarbon into aliphatic and aromatic fractions. A gas chromatograph equipped with a boiling point column (non-polar capillary column) is used to analyze whole soil samples as well as the aliphatic and aromatic fractions to resolve and quantify the fate-and-transport fractions selected by the TPH Criteria Working Group. The method is versatile and performance-based and, therefore, can be modified to accommodate data quality objectives.

Estimates Of Risk For TPH

There are three basic approaches that have been used in the past to estimate potential human health risks posed by TPH contamination. The one most generally applied and most appropriate for evaluation of the carcinogenic risk from TPH is an "Indicator" approach. This approach assumes that the estimated risk from TPH is characterized by a small number of indicator compounds (e.g., BTEX, PAHs). This approach was necessitated by the inability to analyze for the large number of constituents in TPH and the lack of toxicological and other relevant data for many of those constituents that could be individually identified. The indicator approach is generally accepted and used by state regulatory agencies for carcinogenic risk posed by TPH. The use of the indicator approach for determining non-carcinogenic risk has, however, not been fully developed.

Another approach, the "Surrogate" approach, assumes that TPH is not specifically included as an indicator and can be characterized by a single surrogate compound. This approach could overestimate toxicity and mobility because of the compounds typically available for use as surrogates. For example with respect to toxicity, benzene is the surrogate compound for the aromatics; it is also the most carcinogenic. With respect to mobility, benzene is, again, the surrogate compound because it travels at a faster rate than other petroleum constituents. Benzene is, however, the least abundant of the constituents found in petroleum mixtures. A variant of the "Surrogate" approach is the "Whole Product" approach in which

the toxicity and mobility of the TPH product are based on that of a whole product of similar character. Neither the "Surrogate" nor the "Whole Product" approach is capable of taking into account the effects of weathering (i.e., changes in composition and toxicity and mobility over time) and the wide range of mobility of the constituents of the typical hydrocarbon product. Because the lighter and more mobile constituents tend to weather faster, weathered crude oils and hydrocarbon products are typically less mobile and, thus, could pose a lower risk (although mobility is only one of several factors used to determine risk). These approaches are similar to the "Indicator" approach in that they use specific knowledge of a single or a few constituents to characterize the many constituents in a hydrocarbon mixture.

More recently, approaches have been developed which are a compromise between the "Indicator" and the "Surrogate" or "Whole Product" approaches. In these approaches, carcinogenic risk is estimated based on indicators (e.g., benzene and the carcinogenic PAHs) while the non-carcinogenic risk from the TPH is estimated based on a relatively small number of groupings or fractions. Each of these groups or fractions is composed of constituents of TPH that have similar toxicity and mobility characteristics. The risk as a result of TPH contamination can be estimated for each of the groupings or fractions as individual contaminants or for the measured TPH (i.e., the sum of all the groups or fractions) by assuming additivity of risk. The estimated risk approach to TPH developed by the Massachusetts Department of Environmental Protection and the Total Petroleum Hydrocarbon Criteria Working Group are examples of this compromise approach.

TPH Criteria Working Group

The TPHCWG approach is a combined indicator and grouping or fraction approach. Note that the non-carcinogenic indicators (i.e., TEX and non-carcinogenic PAHs) are included in the grouping or fraction analysis and do not need to be analyzed as indicators (although, this can be done if desired by backing them out of the TPH analysis). The basic approach is similar to that developed by MADEP in that the TPH is split into a small number of groups or fractions that have similar properties. The main difference between the approaches is that in the TPHCWG approach, the groups or fractions of TPH are defined based on the potential mobility of the hydrocarbons within each group; in the MADEP approach, they are based on the available toxicity data.

The TPHCWG approach is not a surrogate approach in which the physical/chemical and toxicological properties of the grouping or fractions are based on single surrogate compounds. The physical/chemical and toxicological properties of each of the groups or fractions are based on all available data for individual constituents, well defined mixtures, and/or whole products that are representative of each group or fraction. Thus, the TPHCWG approach is an extension of the MADEP approach, based on a more complete database of physical/chemical and toxicological properties and specifically taking into account the variability in the potential mobility of the petroleum hydrocarbon groups or fractions. The approach developed by MADEP does an adequate job of assessing the risk from TPH for direct exposure scenarios, while the approach developed by the TPHCWG is better suited for addressing cross media exposure pathways such as soil leaching to groundwater.

The TPHCWG has essentially completed its effort and final reports are available on the Internet (<http://voyager.wpafb.af.mil>). The working group is still finalizing the document (Volume 5) which incorporates all of the findings into a sample risk-based decision making framework. The TPHCWG approach is, however, summarized in a technical overview document that is available on the web page and has been presented at numerous conferences and workshops.

Incorporating TPH Into A Risk-Based Corrective Action Program

The petroleum fate-and-transport fractions and toxicity criteria developed by the Working Group can be used in the ASTM/RBCA framework to compare certain fractions obtained from sampling results to previously developed RBSLs or to develop a compound-specific risk-based screening level (RBSL). The soil risk-based screening levels (RBSLs) that are calculated for the indicator compounds and for the fate-and-transport fractions can be used individually as a basis for the management of a contaminated site. In this instance, site remediation will be governed by the most restrictive or lowest soil RBSL. Alternatively, the composition of the total petroleum mixture present at a site can be used to yield a soil RBSL for TPH. The RBSL for TPH is calculated by assuming that the risk for the individual compounds and fate-and-transport fractions can be added, each weighted by their composition in the total petroleum mixture. The Working Group's Volume 5 provides a thorough discussion of how the approach may be used within the RBCA framework, including risk calculations and results from demonstration sites where this new approach has been used.

The approach developed by TPHCWG is intended to provide the technical basis for a broad range of regulatory programs. Thus, while it can be used to develop risk-based analysis for the individual TPH groupings, the approach can also be used to develop a risk assessment or risk-based screening levels for TPH (i.e., the sum of the fractions). In addition, the application of the full analytical method and risk analysis may not be needed for all soil samples collected at a petroleum-contaminated site. Once the petroleum composition has been fully characterized at a site, additional sampling can rely on traditional, less expensive TPH analysis rather than the new Working Group method (if the TPH fingerprint is similar across the site). This simplification can be carried further if process knowledge for a site can be used to characterize the hydrocarbon contamination such that the composition of the petroleum hydrocarbons at the site can be based on non-site specific analysis (e.g., typical jet fuel at an Air Force base).

These simplifications are important for application of the TPHCWG technology at sites where the cost of the more detailed analysis is not justified. For example, the full TPHCWG analysis may not be cost effective at heavy hydrocarbon sites where significant concentrations of the indicator compounds are not anticipated, historical data for TPH does not allow identification of the individual groupings, and/or additional analysis is not cost effective. The full TPHCWG analysis may also not be cost effective for sites such as retail/marketing sites with underground storage tanks where information about the type of hydrocarbon is available (i.e., the contamination is known to be gasoline from an underground storage tank). For these cases, generic risk-based TPH screening levels based on typical composition data (i.e., a typical weather gasoline) can be developed, and less expensive TPH analysis or indicator analysis can be used to characterize the site. The TPHCWG technology can be adapted to fit within and support a broad range of regulatory programs.

One possible use of the TPHCWG technology is to provide the technical basis for the assumption that the risk from TPH other than the indicator compounds (e.g., BTEX and the PAHs) is not significant under certain exposure scenario assumptions. In this case, the risk from TPH contamination would be evaluated based on the analysis of indicator compounds or on some non-risk-based criteria such as the potential mobility of the TPH as a non-aqueous phase liquid or NAPL. Ohio is a good example of a State that has developed a look-up table for TPH based on soil types and the boiling range of the hydrocarbon contamination. The criteria were developed using models to estimate the percent of saturation required for the non-aqueous phase liquid (NAPL) hydrocarbon to be mobile. The States of Hawaii and Louisiana have developed similar policies where the upper limit for TPH screening levels (i.e., 5000 mg/kg and 10,000 mg/kg, respectively) are based on aesthetics or some other non-risk-based criteria.

Another possible use of the TPHCWG technology is to develop generic criteria for TPH based on typical compositions of fresh and/or weathered hydrocarbon mixtures. A good example is a recent analysis of crude oils in the State of Michigan. Analyses of five representative crude oils from across the State were used to support cleanup levels of 10,000 mg/kg. At this concentration of TPH (i.e., 10,000 mg/kg), the concentrations of the carcinogenic indicator PAHs and the TPHCWG fate-and-transport fractions are below levels of concern (i.e., concentrations are less than RBSLs). The state regulatory agency is currently adopting 10,000 mg/kg as a generic screening level for TPH at all crude oil contaminated sites.

NOTE: The technical documents of the TPHCWG are in press or in preparation. Some of these documents are now available or will be soon on the U.S. Air Force Toxicology Division web site (<http://voyager.wpafb.af.mil>). At this web site, Working Group publications may be downloaded from the "recent publications" icon. Additional Working Group resources will be added to this web site as they become available. EPA has neither reviewed nor endorsed the TPHCWG approach. EPA recognizes that TPH may be used as a screening tool for the measurement of total hydrocarbon contamination, but cautions states that it is inconsistent with a risk-based approach that focuses on individual chemicals and their risk to human health.

